Preliminary Results from a Multidisciplinary Geophysical Experiment: Columbia Glacier, South-east Alaska

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ABSTRACT

In June of 2004, we deployed an array of 11 high-frequency and broadband digital seismometers around the lower 10 km of the glacier channel, for a period one year in order to study the characteristics of small seismic events (icequakes) due to ice calving at the terminus, fracturing and crevassing within the glacier and basal sliding. The type of passive-source seismic field experiment proposed here is relatively rare in glacial science studies. Seismic sensors, power systems and recording equipment were obtained through the IRIS consortium PASSCAL program. In June of 2005, we will also deploy several high-frequency seismic sensors on the glacier itself and record two active-source explosions with the goal of better defining ice velocity and thickness.

It is evident that the relevant glacial processes cannot be studied with our Columbia Glacier seismology field experiment alone. For this reason an integrated approach involving collaborations with researchers in global climate change, glacial hydrology, geology, and glaciology, are planned. The seismic network is one component of a larger multi-disciplinary, multi-institutional approach that addresses the problem of the role of calving in glacier dynamics.

Additional studies include:

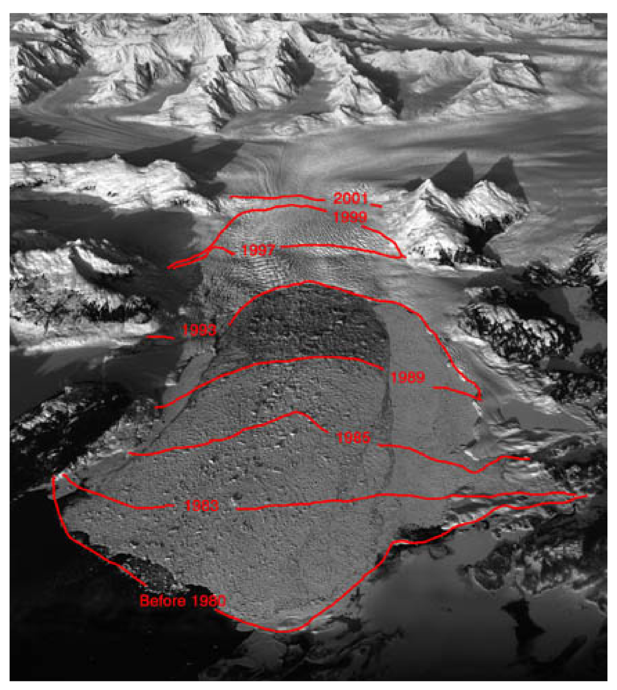
1. continued photogrammetric observations to monitor the retreat of the terminus of the Columbia Glacier [Pfeffer et al., 2002],

2. co-located GPS stations, supplied by UNAVCO, to monitor active ice flow and

3. additional sensors to monitor
   tide levels,
   barometric pressure,
   temperature and
   precipitation.

The main objective of the project is to gain a better understanding of the interactions among glacial calving mechanics, ice fracture processes, and forcing mechanisms such as long-term climate change, seasonal and diurnal thermal variations and tidal interactions, on rapidly retreating tide-water glaciers. Since Columbia Glacier is the last of the Alaskan tidewater glaciers currently retreating rapidly, it is imperative that this type of study be conducted before the rapid retreat ends and this natural observatory disappears

We anticipate that results from this proposed project will be highly pertinent to the glacier/climate interaction debate. In addition to increasing our understanding of fundamental ice-processes, results from the proposed project have implications for important societal issues such as global climate change.



History of Columbia Retreat

(photo by R.M. Krimmel USGS)

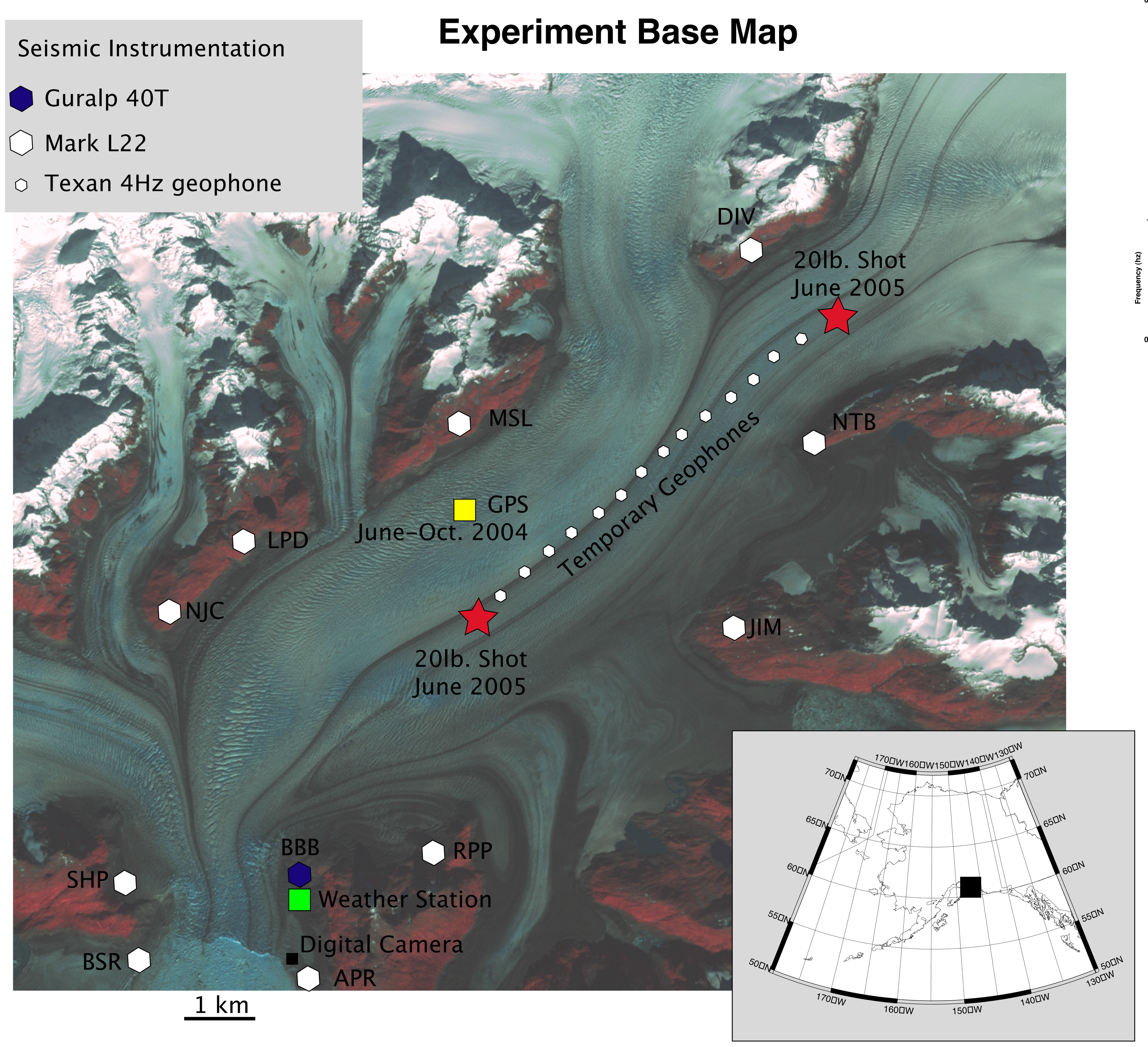
Columbia Glacier is a large tidewater glacier, ending at an iceberg-calving terminus in Prince William Sound, 35 km west of Valdez, in south-central Alaska. It is presently one of the world's fastest glaciers with an annual average speed at the terminus of approximately 11 km/yr (30 m/day). The glacier is discharging ice into Prince William Sound at rates in excess of 10 km3/yr [O'Neel et al., in press]. The retreat is driven by iceberg calving that exceeds incoming ice flux at an average rate of 0.74 km/yr [Pfeffer et al., 2002]. This value does not include rapid dynamic thinning that exceeds 7.4 m/yr averaged over the entire glacier area, and 20 m/yr at the present terminus [O'Neel et al., in press; Arendt at al. 2002]. Such retreats are irreversible until the terminus reaches a location where the bed rises above sea level, and may be analogous to the rapid breakup of historical ice sheets such as the Laurentide.

June 2004 Field Work



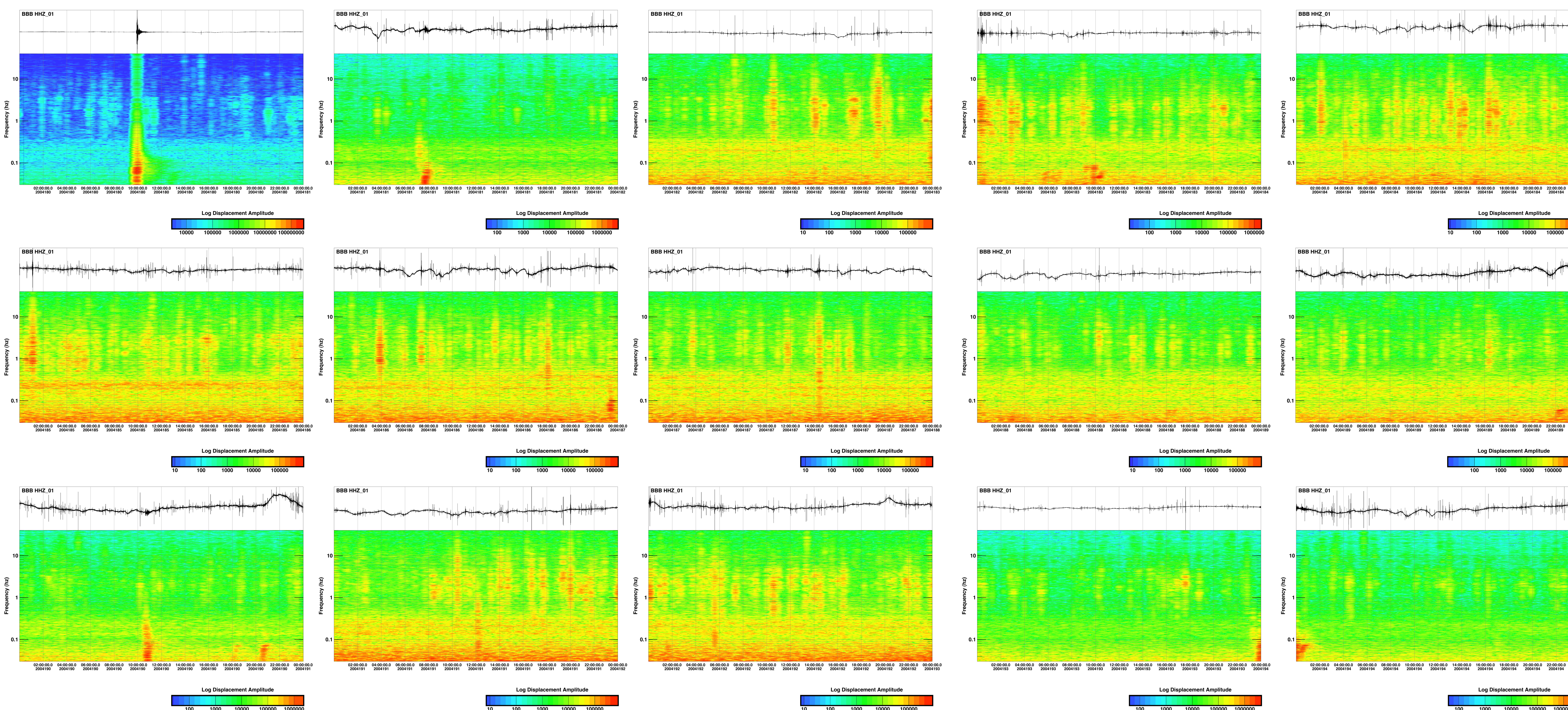
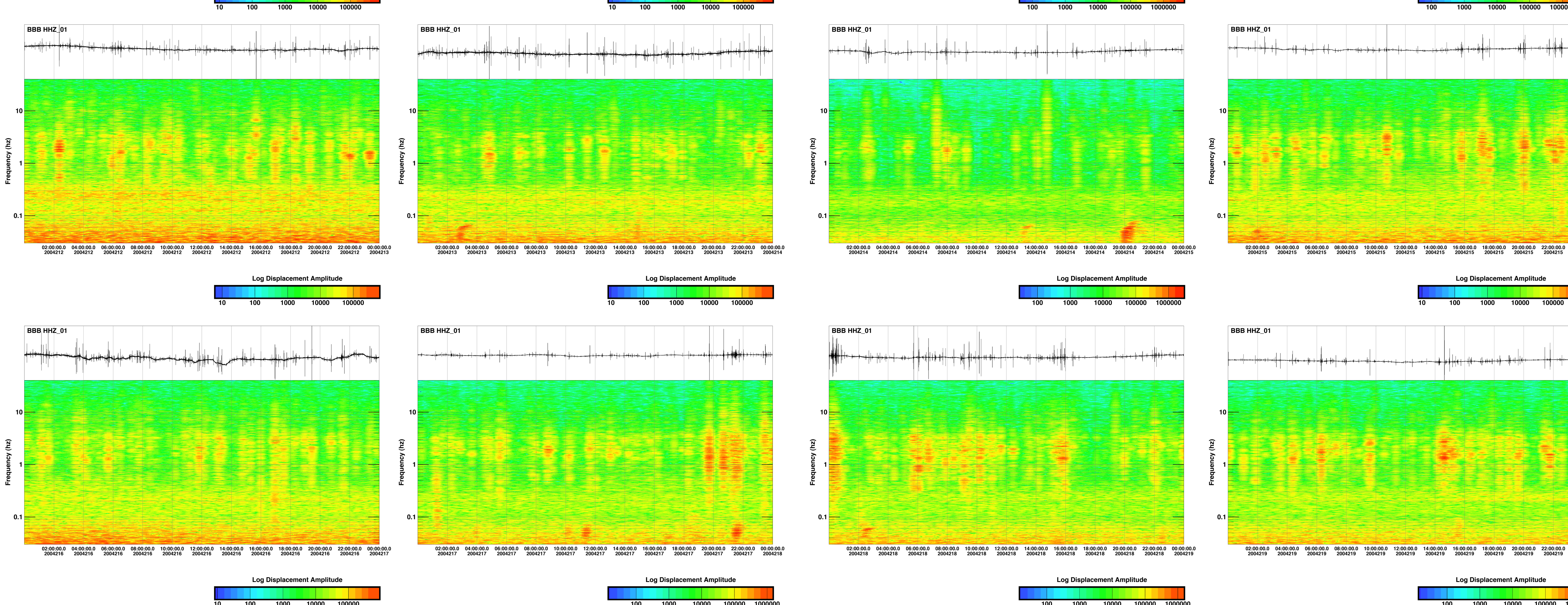


Experiment Base Map

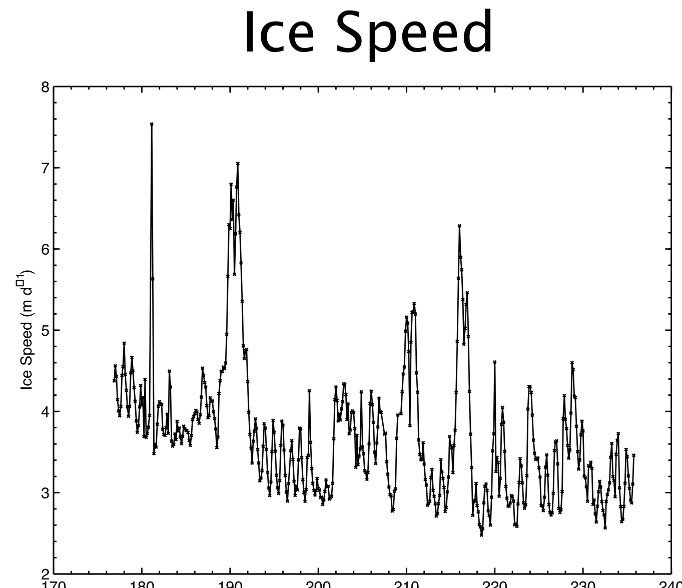


Spectograms for Station BBB

Seismic activity correlates well with ice velocity increases and terminus area change events. (see graphs below)

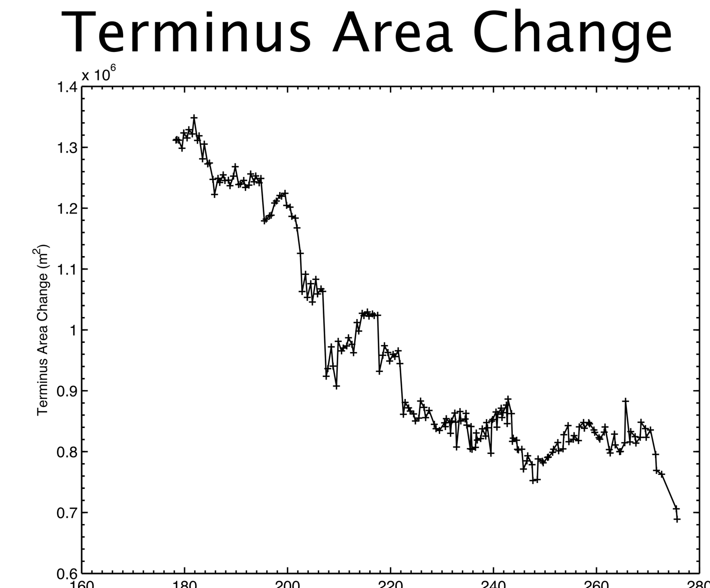



Ice Speed



To compute ice speed a Trimble 4000 GPS receiver, on the ice, roughly 7 km above the terminus, with a basestation located at camp. The instrument recorded 8 30 minute recordings every day, at 1 sample every 30 seconds.

Terminus Area Change



Areal photogrammetric observations were used to compute the change in ice area at the terminus. This can be used a a measure of calving rate.

June 2005 Field Work Plans

In June of 2005, we plan to conduct the following experiments before pulling the seismic network.

1. Active source seismic survey, to determine a good seismic velocity model.

2. Optical ice Velocity survey, to measure ice velocity near the terminus.

3. Continued GPS observations on the ice, to measure ice velocity above the terminus.

Summary

The main objective of the proposed project is to gain a better understanding of the interactions between tidewater calving mechanics and fracture mechanics, and the mechanisms that may force retreats such as climate change and buoyancy instabilities. Since Columbia Glacier is the last of the Alaskan tidewater glaciers to begin rapid retreat, and has a 30+ year observational record, it is imperative that this type of study be conducted before the rapid retreat ends and this natural observatory disappears.

Acknowledgements

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